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How Body Pressure Distribution Can Map Soldier Comfort

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Map Soldier Comfort
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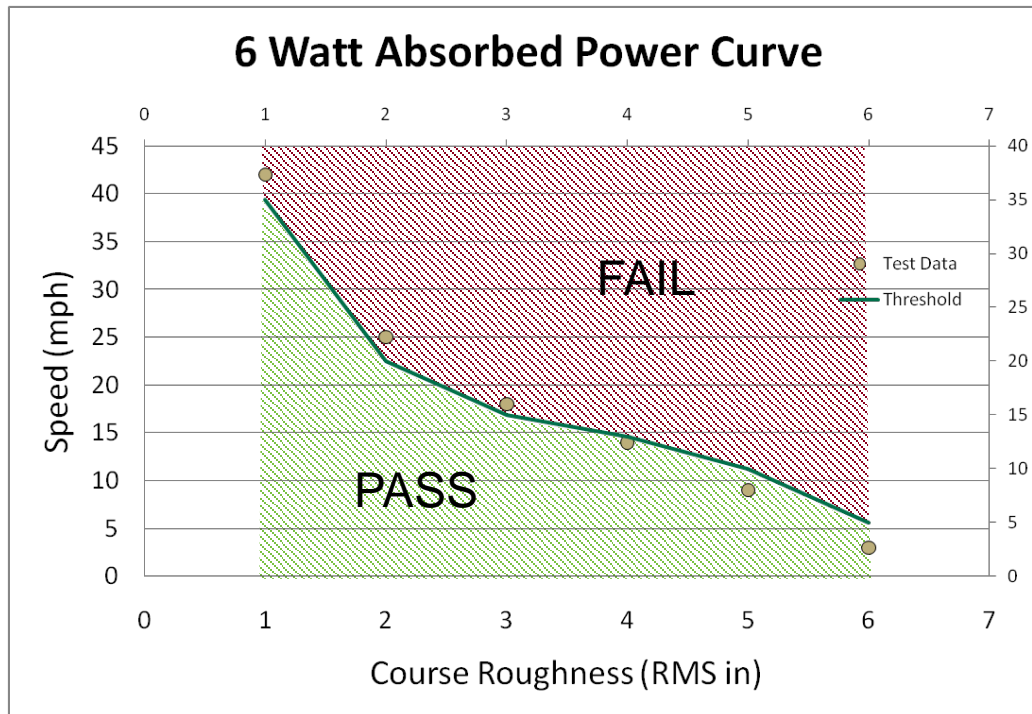
- Background
 - Comfort Metrics
 - Absorbed Power
 - Pressure Change Rate Root-mean-square (Pcrms)
 - Area Pressure Change Rate (aPcrms)
 - Seat Pressure Distribution (SPD%)
- Military Environment
 - What makes it unique?
- Case Studies
 - Mine Resistant Ambush Protected (MRAP) Seat Enhancement
 - High Mobility Multipurpose Wheeled Vehicle (HMMWV) Seat Upgrade
- Conclusion

- Absorbed Power

- Human tolerance threshold ~6 Watts
- Army's primary ride quality metric

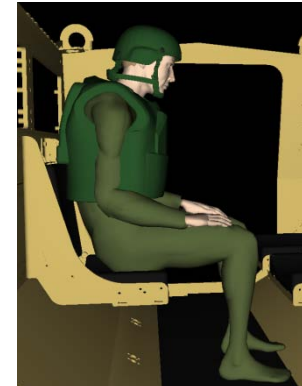
$$AP = \sum_{i=0}^N K_i A_i^2 rms$$

- $K_i \equiv$ Conversion constant, function of the frequency i
- $A_i rms \equiv$ Root mean square of the acceleration

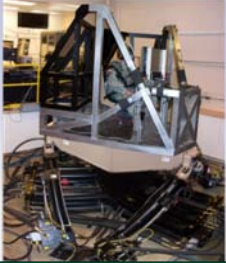


- Seat Pressure Distribution (SPD%)
 - Seat's ability to uniformly distribute pressure.
 - $$SPD\% = \frac{\sum_{i=1}^n (p_i - p_m)^2}{4np_m^2}$$
 - $n \equiv$ total number of nonzero cell elements
 - $p_i \equiv$ pressure at the i^{th} cell
 - $p_m \equiv$ mean pressure of the n elements
 - Lower values describe more uniform pressure distribution.
- Pressure Change Rate Root-Mean-Square (Pcrms)
 - Ability of the seat to absorb sudden changes in vibration
 - $$Pcrms = \left\{ \frac{1}{T} \int_0^T \left(\frac{dP(t)}{dt} \right)^2 dt \right\}^{1/2}$$
 - $T \equiv$ time period
 - $P(t) \equiv$ dynamic pressure history
 - A lower value shows a more comfortable seat

- Gear Worn
 - Affects seating position and posture.
 - Makes measurements on seat back difficult.

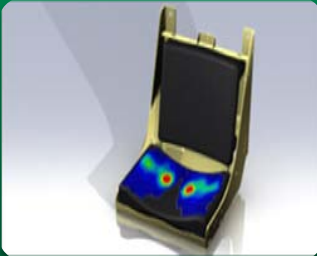


- Road Roughness
 - Automotive: 0.058–0.193 g's RMS
 - Military: 0.069–0.362 g's RMS
 - Harder to test, rougher on occupant
- Operational Environment
 - Exit quickly and ready to fight.
 - Alert to threats while on the move.



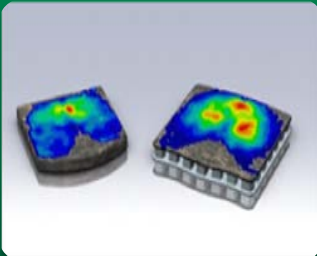
Test Location

- U.S. Army TARDEC, Warren MI
- Ride Motion Simulator (RMS)



MRAP Troop Seat Enhancement

- Developed, tested, and fielded comfort enhancement



HMMWV Seat Cushion Upgrade

- Analyze proposed cushion against baseline cushion

- Objective
 - Improve comfort with an add-on piece.
 - 2 enhancement designed and tested



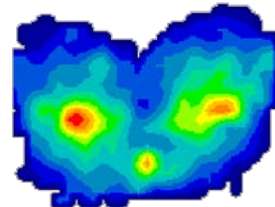
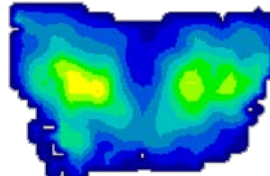
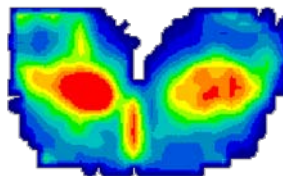
Baseline



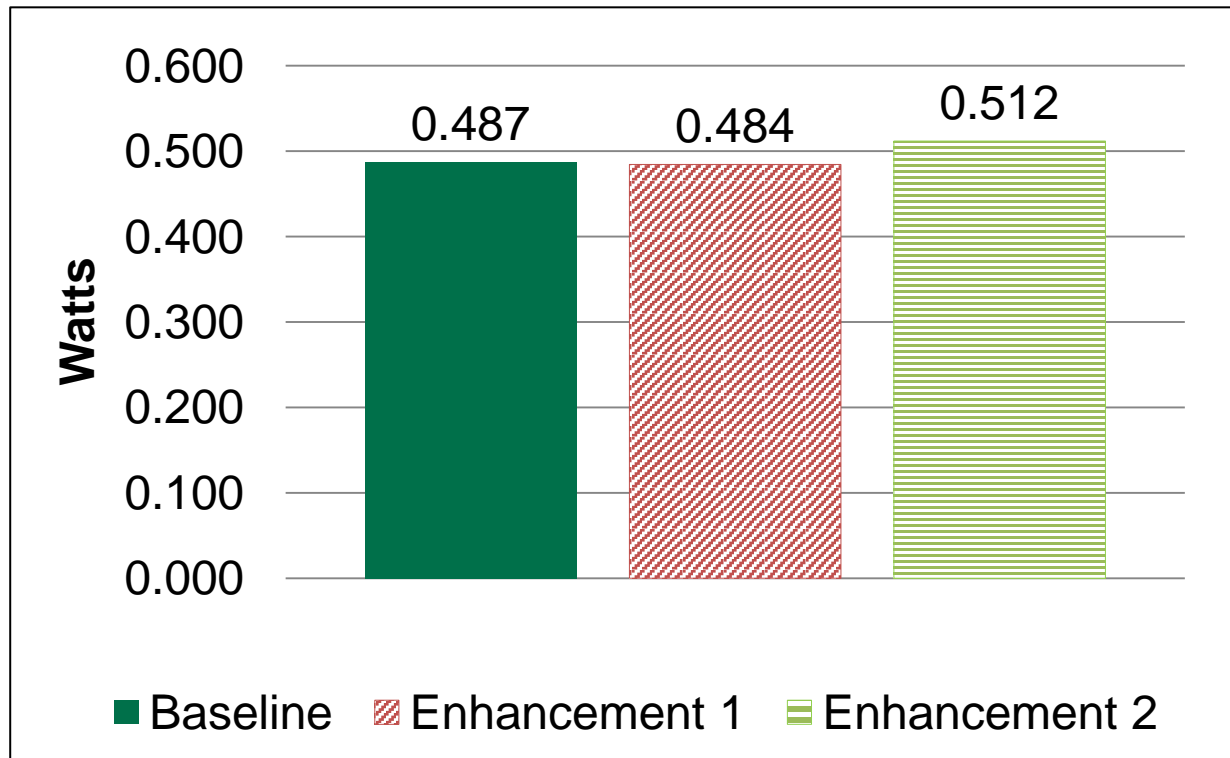
Enhancement 1



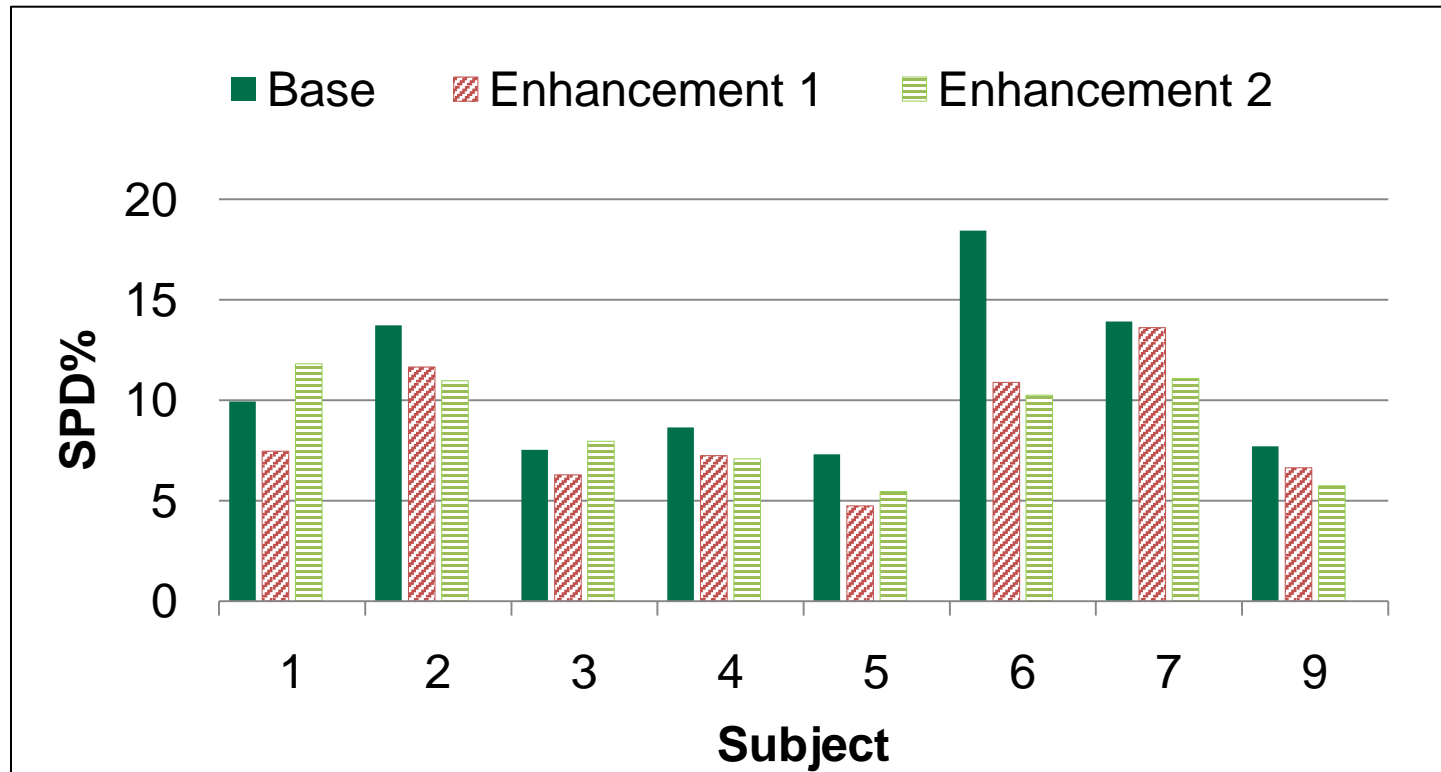
Enhancement 2



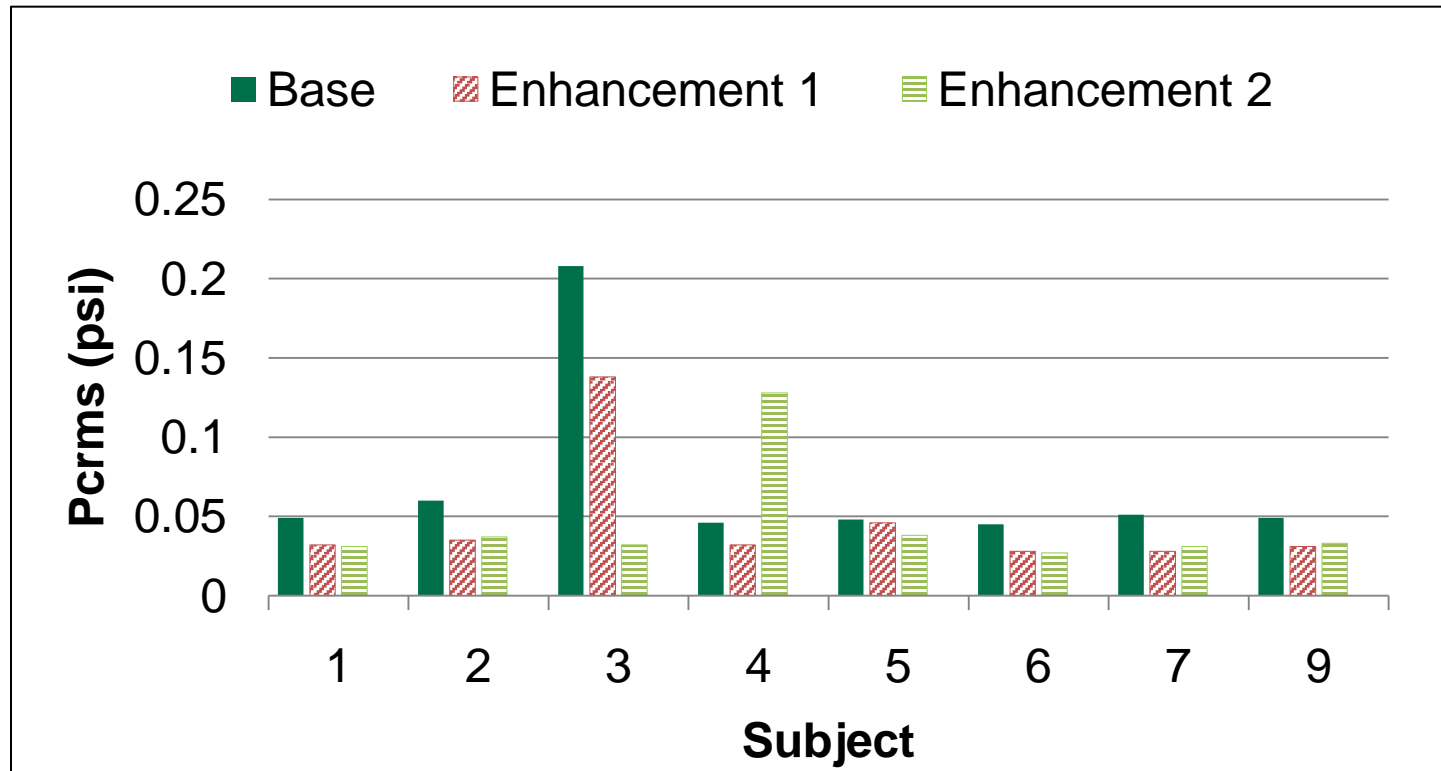
- Absorbed Power
 - Ineffective measure
 - Vibration at ischial tuberosity too similar on different seats



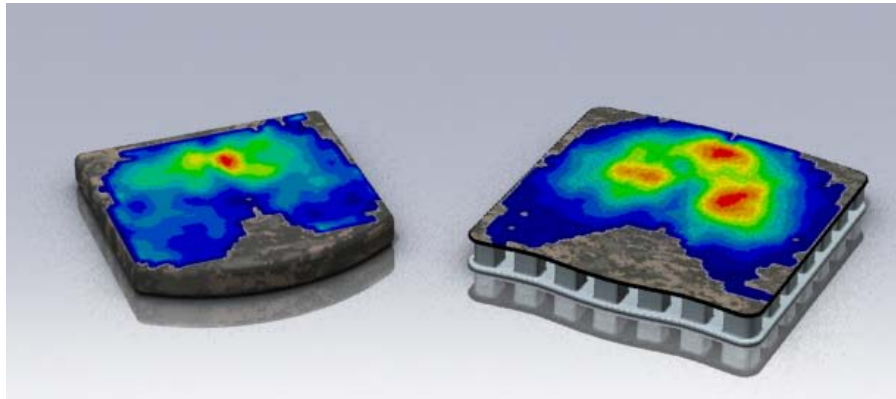
- Seat Pressure Distribution (SPD%)
 - Inconsistent but enhancements show improvement



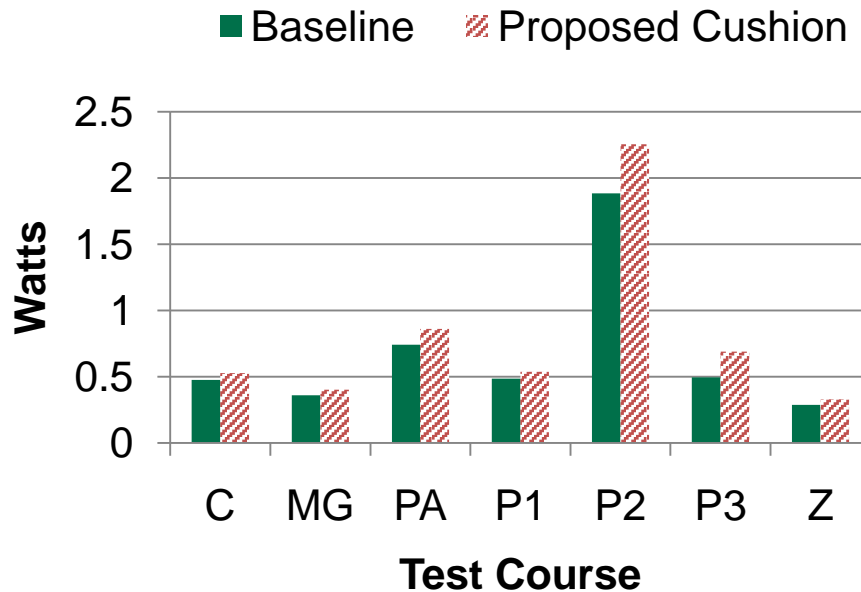
- Pressure Change Rate Root Mean Square (Pcrms)
 - Inconsistent but enhancements show improvement
 - Small deviation



- Objective
 - Analyze proposed cushion against baseline cushion
- Seat Cushions
 - Baseline: typical automotive open cell foam
 - Proposed: soft plastic shock absorbing structure



- Absorbed Power
 - Baseline Preformed better than proposed cushion



C - Churchville

MG - Munson Gravel

PA - Perryman A

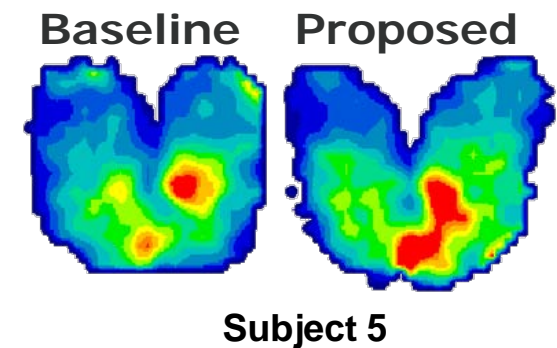
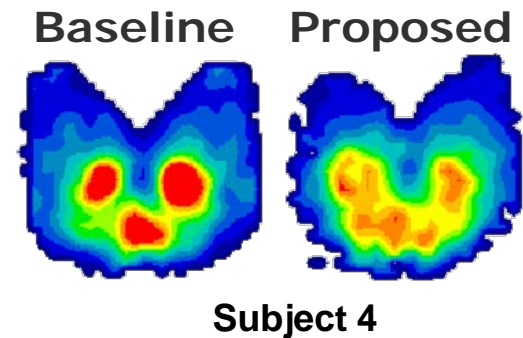
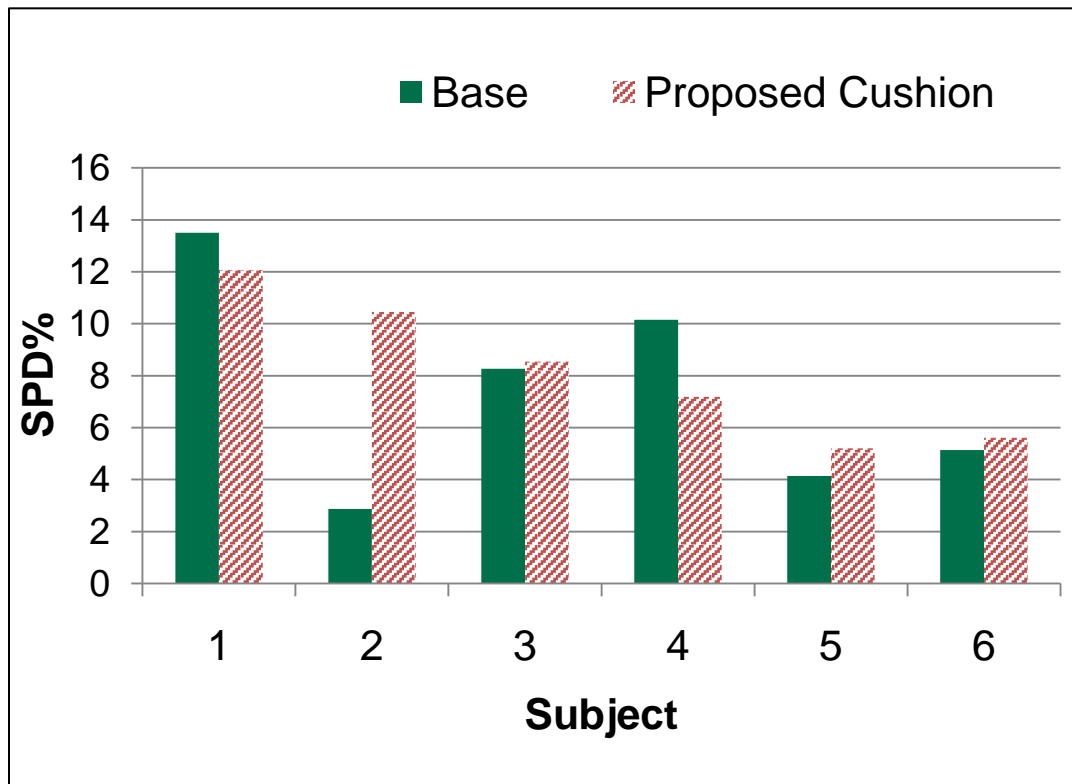
P1 - Perryman 1

P2 - Perryman 2

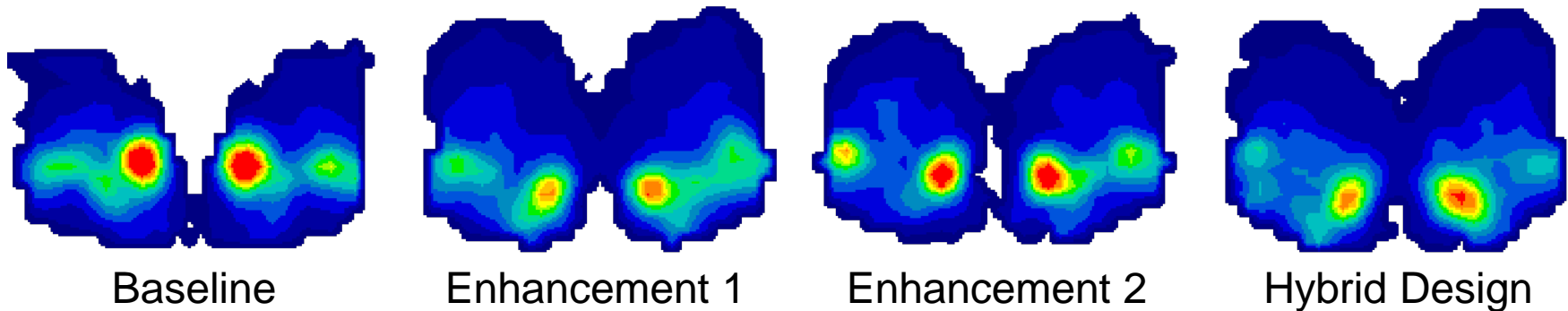
P3 - Perryman 3

Z - Z-direction white noise

- Seat Pressure Distribution (SPD%)
 - Inconsistent which seat was better



- MRAP Crew Seat Enhancement
 - Enhancement designs were combined
 - Final design fielded to theater



- HMMWV Seat Cushion Upgrade
 - No significant comfort increase with proposed cushion
 - Proposed cushion not integrated

- BPD shown to help describe a military seat's comfort
 - Compliments but doesn't replace absorbed power.
- Metrics can only compare seats subject dependent.
- Difficult to measure interaction of subject, body armor and seat back.
- Best test method needs to be determined.
- Until process can be refined, questionnaires and other subjective data is still needed in seat evaluations.